

CODING ACTIVE INFERENCE

From Simple Agents to Edge Intelligence

<https://github.com/cerkut/D3A-AIF-Starter>

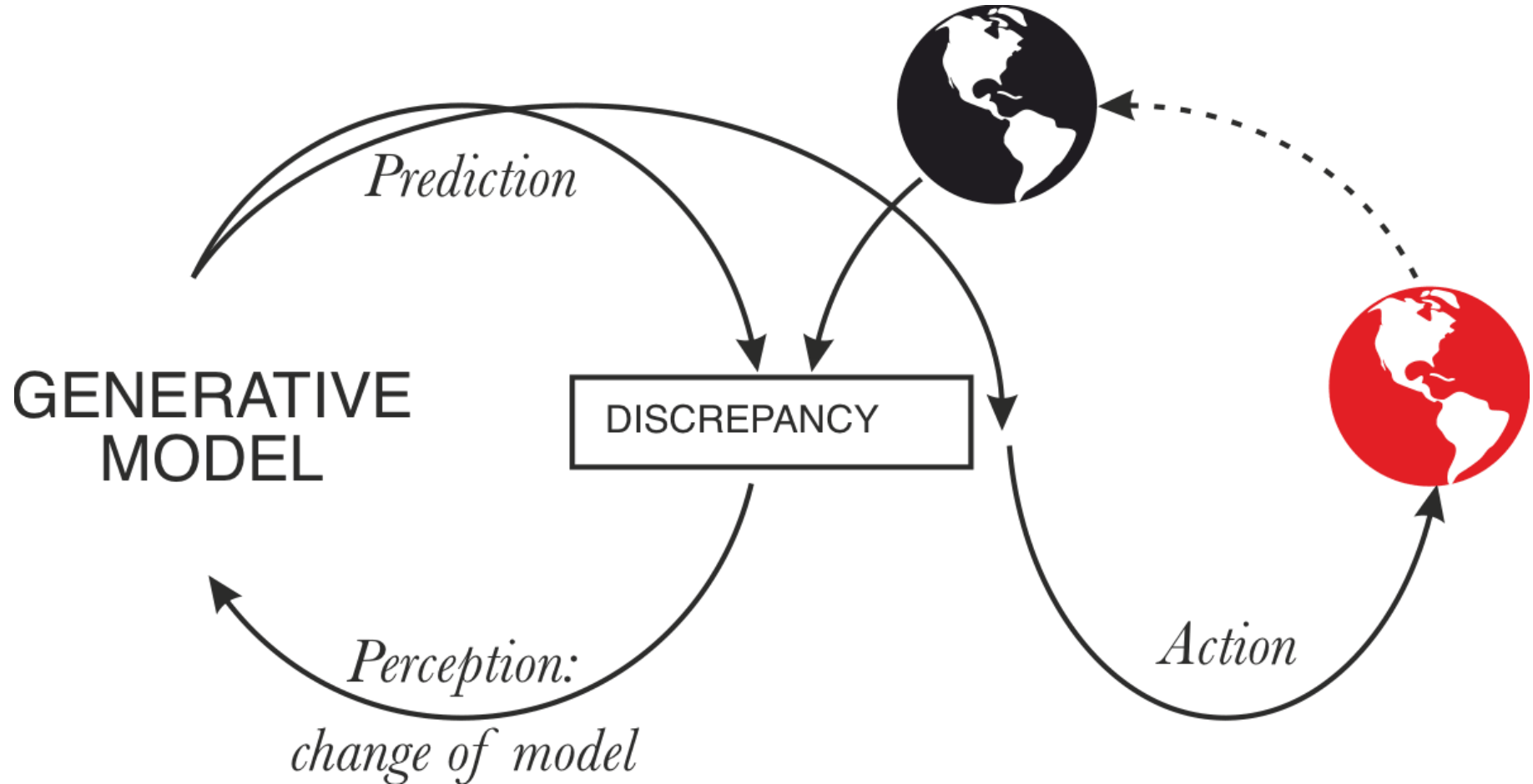
CUMHUR ERKUT
DEPT. OF ARCHITECTURE, DESIGN AND MEDIA
TECHNOLOGY (CREATE)

Remember: November 13-15, 2024 <https://symposium.activeinference.institute>



AALBORG UNIVERSITY
DENMARK

Active Inference for Multisensory Experience



PROBLEM



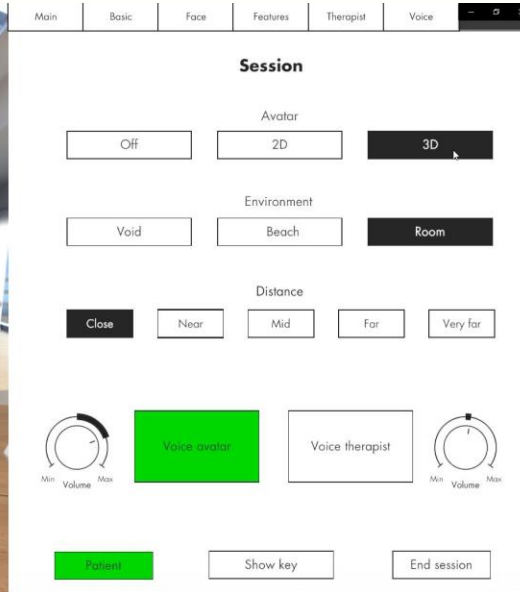
30% of patients with schizophrenia treatment-resistant
Meltzer H.Y. (1997)



those whose symptoms get better from medication experience terrible side-effects and often discontinue taking their meds
Lieberman, J. A., et al. (2005)



This is the most expensive disease to treat in psychiatry
Kadakia A. et al, 2022, Christensen, M.K. et al, 2022, Fasseeh A. et al., 2018,



T-shaped profile combining sound, music, and motion with AI/XR for real-time deployment with MLOps

Real-time Processing of Traditional Music with Differentiable DSP

Background: Each real-time generative model challenges us in code, model, data, and operational practices.

Example 1: Resurrecting Tromba Marina.

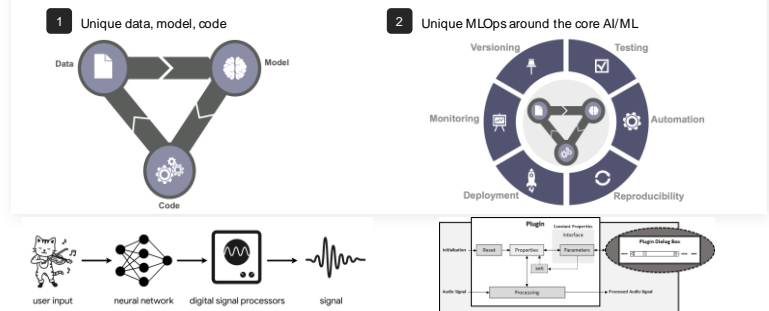
Also Flamenco, Nordic and Middle Eastern traditions.

Example 2: Generative Choreographies combining

sound, music, and movement. Also therapy.



Methods



Aim: Keep the interested, motivated, and contributing graduates in Denmark



Towards Multimedia Edge Intelligence with Active Inference



Top: 3 scenario pilots at the lab. a) Workshop with XR-enabled EI musical instruments during a visit from University of Oslo. b) Social movement exercises with adolescents on the autism spectrum c) Movement therapy and feedback with Zed Cameras on Jetson Orin. Bottom: starting EI-enabled research instrumentation at the lab.

Towards Multimedia Edge Intelligence with Active Inference



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POMDP generative models

Partially Observed Markov Decision Process

$$P(o_{1:T}, s_{1:T}, \pi, \phi) = P(\phi)P(s_1)P(\pi) \prod_{\tau=2}^T P(s_\tau | s_{\tau-1}, \pi; \phi) \prod_{\tau=1}^T P(o_\tau | s_\tau; \phi)$$

$P(o_t s_t, \mathbf{A})$ “Observation model” “Sensory likelihood mapping”	A
$P(s_\tau s_{\tau-1}, \pi, \mathbf{B})$ “Transition or dynamics model” “Dynamical mapping”	B
$P(o \mathbf{C})$ “Prior over observations” “Prior preferences”	C
$P(s_1 \mathbf{D})$ Prior over initial hidden states	D

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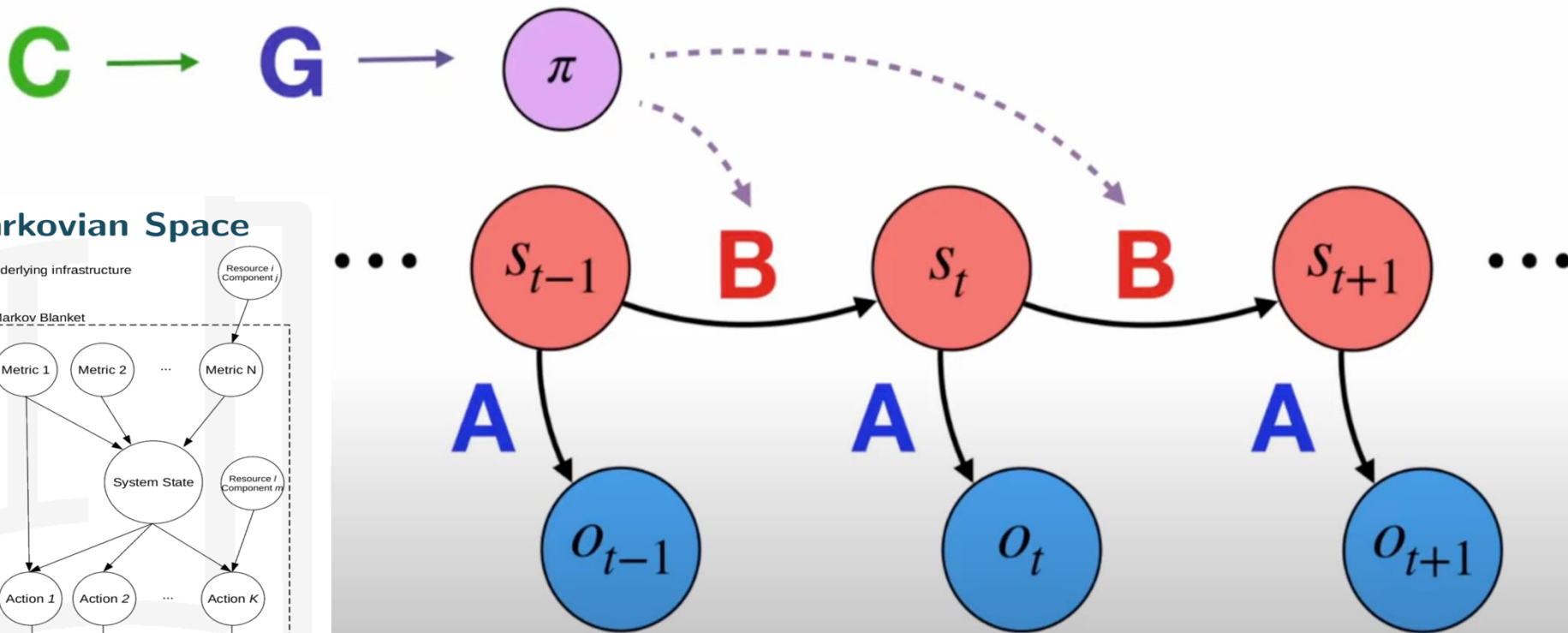


Table 3: Open Source Code for the Free Energy Principle.

	Reference	Task	Link	Language
Classical active inference	(Da Costa et al., 2020)	Linear generative model	https://www.fil.ion.ucl.ac.uk/spm	Matlab
	(Heins et al., 2022)	Discrete state space	https://github.com/infer-actively/pymdp	Python
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Zhang, Zhengquan, and Feng Xu. 2024. “An Overview of the Free Energy Principle and Related Research.” Neural Computation 36 (5): 963–1021. doi:10.1162/neco_a_01642.

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Overview



Matlab code

Run demo

DFP_demo_double_well:

DEMO comparing Variational filtering with particle filtering in the context of a bimodal conditional density. This demonstrates that the variational filter can not only represent free-form densities on the states but also the causes of responses.

(GNI) Copyright (c) 2005 The Wellcome Trust Centre for

Static Models

General Linear Model

Factor Analysis

Emprical Bayes

Figure-ground

Sparse regression

PEB with BMR

+

Variational Filtering

Linear deconvolution

Double-well

Generalised Filtering

Triple estimation

+

Phase-space reduction

Hemodynamics

Cubature filtering

Perceptual learning and inference

Bird-songs and priors

Mismatch negativity

Categorisation

Position invariance

Omission responses

Face recogniton

Cognitive neuroscience (continuous states)

Biased competition

Action-observation

Cornsweet illusion

Slow pursuit

MMN and latency

Visual search

Visual occlusion

Oculomotor delays

Sensory attenuation

Evidence accumulation

Behavioural modelling

Meta-modelling

Nosology

Choice modeling

+

Dynamic Models

Ornstein-Uhlenbeck

Bayesian filtering

Deconvolution

+

Lorenz attractor

+

Dual estimation

Double-well

+

Triple estimation

Contact lens

DEM and Kalman filtering

Image deconvolution

Variational Laplace and dynamic causal modelling

Stochastic DCM for fMRI

Large DCM for fMRI

Spectral DCM for fMRI

Emprical Bayes for DCM

Eigenmodes and DCM

Bayesian model reduc...

Active inference

Attractor dynamics

Mountain car

Visual tracking

Reaching

Motor trajectories

Writing

Behaviour and learning (dynamic)

Addiction and SHC

Cost and divergence

Heteroclinic channels

Affordance and cues

Agency and MDP

Eyeblink conditioning

Behaviour and learning (discrete)

Waiting game

Urn or beads task

Trust games

Epistemic value

Habit learning

+

Visual foraging

Reading

Artificial curiosity

Mixed models

Maze learning

Decisions to movements

Interception

Evidence accumulation

Movement planning

Hierarchical (empirical) Bayes

General Linear Model

Bayes factors

PEB group inversion

Lindley paradox

Simulated EEG analysis

Intelligent optimisation

PEB & grand averages

Information gain

PEB & session effects

CVA & RSA

Communication and multiagent games

Birdsong duet

Morphogenesis

Niche construction

Self-organisation and dynamics

Life as we know it

Loss and surprise

Criticality and slowing

Learning and entropy

Synaptic selection

Cells of cells

+

Sentient physics

Markov Blankets

Physics & blankets

Self organisation

Self entropy

Stochastic chaos

Paths of least action

Deterministic chaos

Physiological models

Hemodynamics

Coupled oscillators

DCM & blankets

Voice recognition and language

VR setup

Segmentation and P300

Dictation

20 questions

+

Voice recognition

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Note that the table does not enlist Reactive Message Passing (Julia): <https://github.com/ReactiveBayes>
Nor <https://github.com/ilabcode/ActiveInference.jl>

Overview of today's material

A, B, C, D

Make an active inference agent using `Agent(A = A, B = B, C = C, D = D)`

Specify a task environment (i.e. an `env()` class)

Run active inference loop!

Insert Web Page

This app allows you to insert secure web pages starting with https:// into the slide deck. Non-secure web pages are not supported for security reasons.

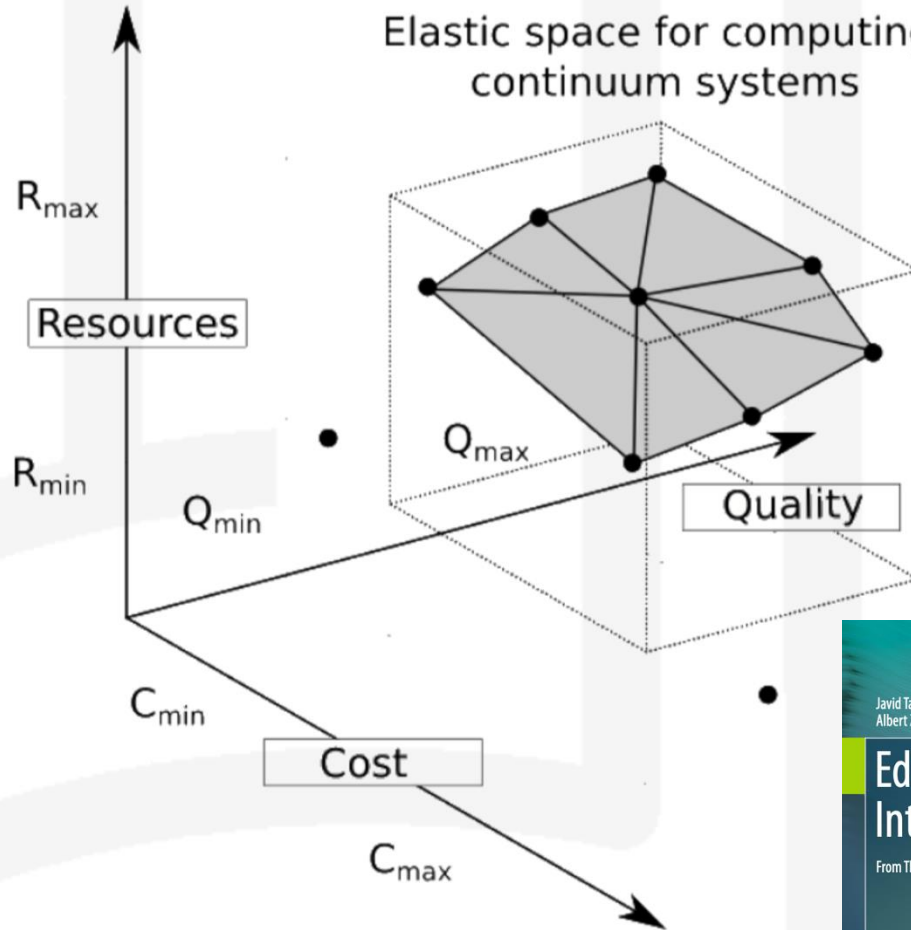
Please enter the URL below.

https:// pymdp-rtd.readthedocs.io

Note: Many popular websites allow secure access. Please click on the preview button to ensure the web page is accessible.

Cartesian Blanket

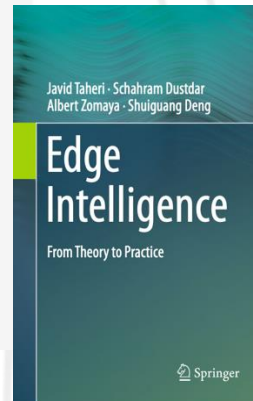
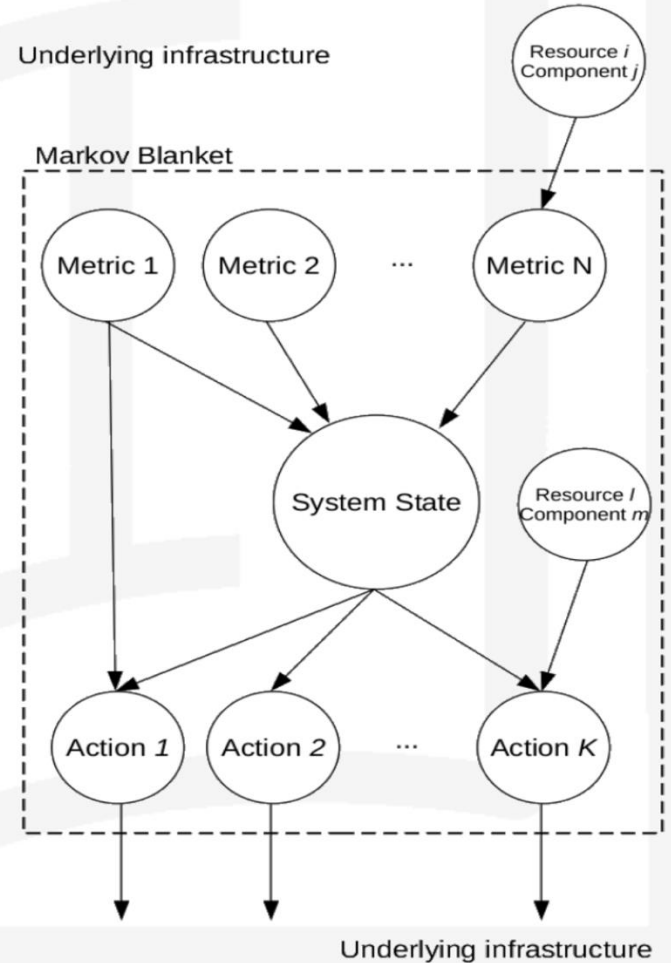
Elastic space for computing-continuum systems

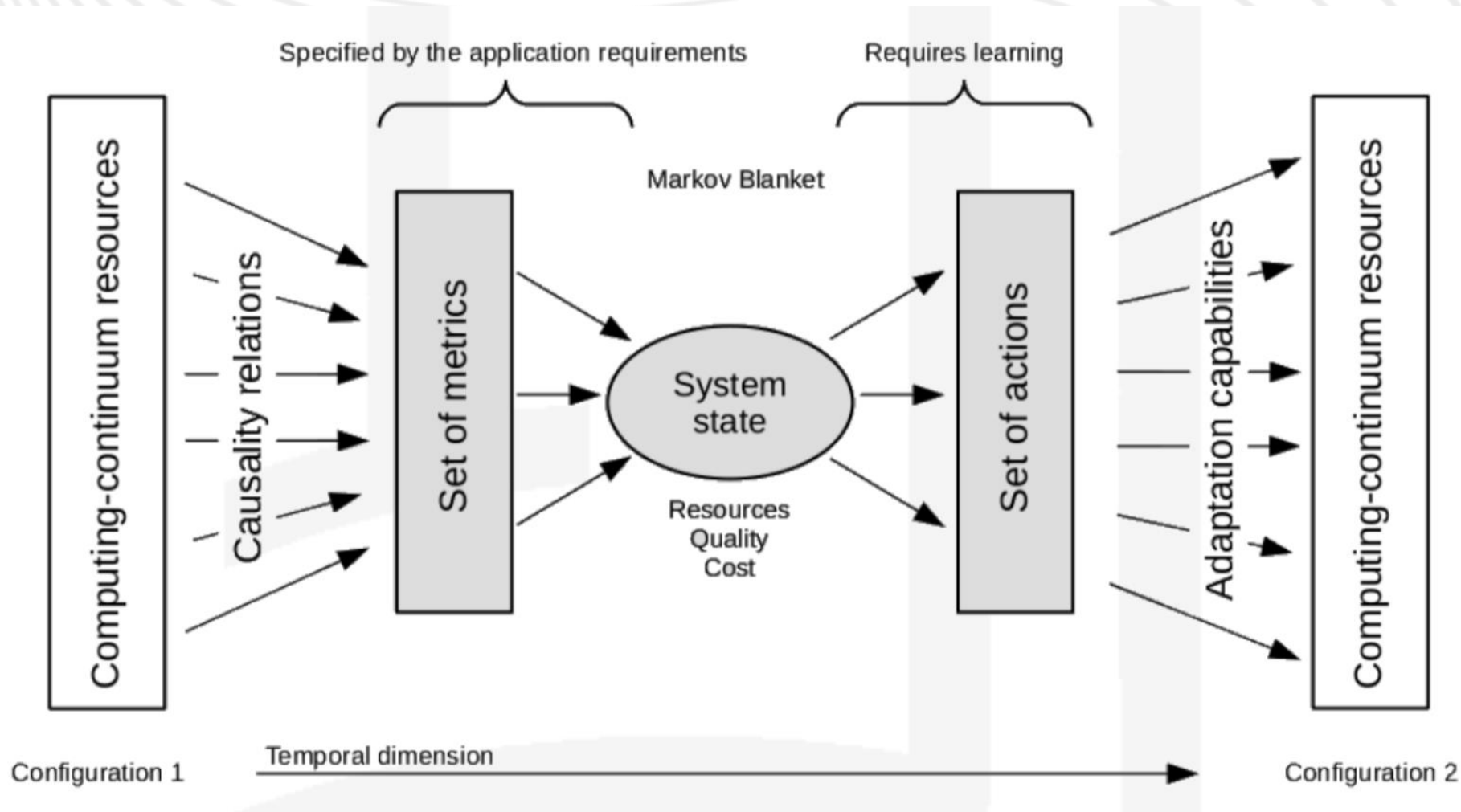


Markovian Space

Underlying infrastructure

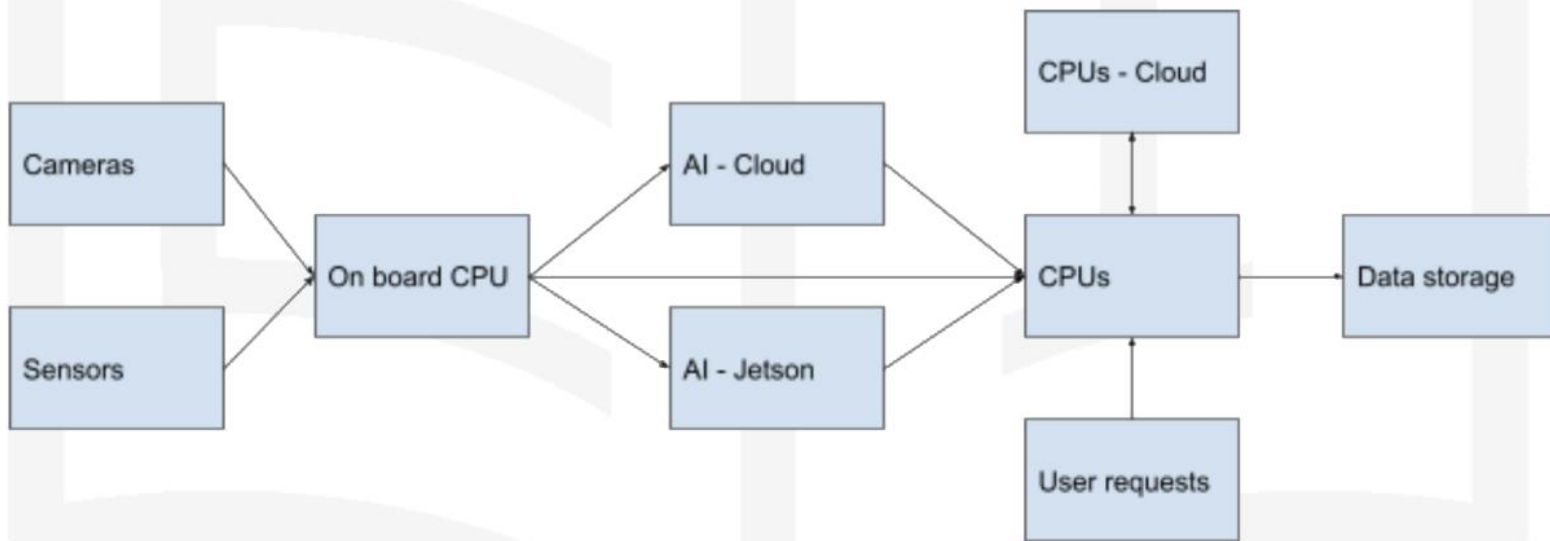
Markov Blanket







Application Description



Developing the DAG

